

NASA Exploration Senior Design Project List

Integrate ESMD-provided mission challenges into university senior engineering design courses.

ESMD-related design projects will be identified by ESMD each year. Funds can be used to support student senior engineering design projects (i.e. to buy materials, build prototypes, etc.) or to bring in subject matter experts to consult with the class.

Senior Design faculty may request funding for these projects by completing this form:

<http://spacegrant.org/esmdsg/forms/?form=design>

NASA senior design projects are subject to change and contingent on project funding, mentor availability and management approval.

Ames Research Center (ARC)

Small Spacecraft

ARC1-04-SD, Spacecraft

Small spacecrafts show great promise for future NASA missions. Because of their nature, these spacecraft typically have very low margins in mass, power, and propulsion. In order to make these systems viable, NASA needs evaluate what is possible with innovative concepts for microspacecraft landers, rovers, and communications relays that could be used for very low cost robotic lunar precursor missions.

NASA Technology Database

ARC2-05-SD, Ground Operations

Assist researchers in the determination of technology that affect the ESMD mission using the next generation of NASA Technology Database and exploring approaches for improving NASA Technology Transfer meeting OMB Requirements. Senior design team will help model aspects of the technology descriptions and maturity control and collect and analyze data as needed.

Complex Systems - Damage Propagation

ARC2-06-SD, Ground Operations

The Prognostics Center of Excellence at NASA Ames Research Center is conducting research in systems health management. This involves the early assessment of abnormal conditions and damage as well as the estimation of "remaining life" of a component or subsystem. The goal is to research damage propagation mechanisms and to model damage using a physics-based approach for select application domains (e.g., power semiconductors, electro-mechanical actuators, composite structures, batteries).

Prognostics for Complex Systems
ARC2-07-SD, Ground Operations

The Prognostics Center of Excellence at NASA Ames Research Center is conducting research in systems health management. This involves the early assessment of abnormal conditions and damage as well as the estimation of "remaining life" of a component or subsystem. The goal is to contribute towards the state of the art in uncertainty management which is a critical component of prognostics.

FDIR Tool and Simulation Evaluation-1
ARC2-10-SD, Ground Operations

Build a simulation of the FDIR generic LH2 subsystem, the Constellation (CxP) Ground Ops LCS Blue Wagon Test Bed (fluid loading operations) or the Ames Research Center ADAPT (power management) Test bed. Nominal and off-Nominal data will be provided by NASA to validate student simulations.

FDIR Tool and Simulation Evaluation-2
ARC2-11-SD, Ground Operations

Build a model of the FDIR generic Liquid Hydrogen subsystem, the CxP Ground Ops LCS Blue Wagon Test Bed (fluid loading operations) or the Ames Research Center ADAPT (power management) Test Bed using a tool or algorithm which performs anomaly detection, fault detection, fault isolation, fault recovery (automated recovery or recovery recommendation) or prognostics. tool evaluation criteria include figures of merit such as speed of diagnosis, accuracy, usability, ease of model integration and ease of model maintainability. the tool or algorithm tested must be acquired by the evaluator.

Prognostics Analysis
ARC2-12-SD, Ground Operations

Analyze design specifications of generic hardware components (valves, sensors, transducers, relays, data acquisition modules, etc.) to identify the component dynamics/characteristics necessary to model in order to perform prognostics on a component or class of components.

Automation Tools 1
ARC2-13-SD, Ground Operations

Develop tool(s) to automate the generation of all or a portion of a TEAMS Designer subsystem model (requires purchase of TEAMS Designer license).

Automation Tools 2

ARC2-14-SD, Ground Operations

Develop tool(s) or method(s) to automate the accreditation (verification) of a TEAMS Designer model (requires purchase of TEAMS Designer license) or a TEAMS-RT dependency matrix (requires purchase of TEAMS-RT Development license).

Automation Tools 3

ARC2-15-SD, Ground Operations

Develop tool(s) to automate the generation of an Inductive Monitoring System knowledge base.

Automation Tools 4

ARC2-16-SD, Ground Operations

Develop tool(s) or method(s) to automate the accreditation (verification) of an Inductive Monitoring System knowledge base.

Fluidized Bed Synthesis of Carbon Nanotubes

ARC4-08-SD, Spacecraft

The project involves producing carbon nanotubes in large enough quantities to fabricate composites for civil and space aviation.

Photonic/Electronic Impact Detector for Orion

ARC4-09-SD, Spacecraft

Further advance a detector to determine the extent of MMOD damage to the Orion vehicle for its ISS and Lunar missions. The detector has a low false positive rate, uses minimal spacecraft resources and is based on a DoE system used to determine strikes on ballistic missile targets.

Dryden Flight Research Center (DFRC)

Lunar Landing Training Vehicle

DFRC1-15-SD, Lunar and Planetary Surface Systems

This projects seeks senior design concepts for Lunar Landing Training Vehicles. The concepts must account for reduced lunar gravity, and allow the terminal stage of lunar descent to be flown either by remote pilot or autonomously. Platform should allow for both sensor evaluation and pilot training.

Aero-Assist for Mars Surface Sensor Deployment
DFRC1-17-SD, Lunar and Planetary Surface Systems

Aero-Assist Options for Mars Surface Sensor Deployment-This projects seeks senior design concepts for using aero-assist to deliver a constellation of small sensors to the surface of Mars. In this study the surface delivery of pico-sat sized sensors using ONLY aerodynamic deceleration will be addressed. Study should identify aero-shell geometry, required L/D ratios, mass fractions, launch options, and number and size of sensors deliverable to the Mars surface. Class of allowable ballistic coefficients for sensor packages, and required parachute/decelerator systems should be described.

Propulsions Systems-Planetary Gravitational Simulator
DFRC3-16-SD, Propulsion

This projects seeks senior design concepts for propulsion or lift-system concepts for gravity offset for a Lunar Landing Training Vehicle (LLTV). Project should perform trades to evaluate the most effective and reliable methods for gravity offset. Potential methods include roto-craft, jet engines, small rocket systems, and cold-jet lift concepts. Issues to be addressed include scalable lift mass, reliability, onboard propellant mass fractions, and vehicle stability/handling qualities.

Glenn Research Center (GRC)

Extreme Environment Lander Design
GRC1-07-SD, Lunar and Planetary Surface Systems

The goal of this project is to develop a conceptual lander design capable of long-term operation under extreme environmental conditions. The design must provide sufficient power and environmental protection for a pre-selected set of scientific instruments. A 3D CAD model of the lander is required to provide thermal and stress analysis, as well as to determine packaging and overall system mass.

Mechanical Components for Cryogenic Tank
GRC3-06-SD, Propulsion

Cryogenic propellant tanks, such as those used for the Lunar Lander, are rather complex systems with many electro-mechanical components for fuel supply, thermal control, pressure control, and low gravity propellant gauging. The objective of this senior design project opportunity is to consider the operability and reliability of those mechanisms inside or connected to the tank where the operating temperature range is extremely large. Thermal expansion of mechanical components, materials to withstand thermal cycles, sizes and weights of the mechanisms are some of important considerations.

Mini “Moving Liquid” Gyroscope for Small Spacecraft GRC4-09-SD, Spacecraft

A student team will be posed the challenge of designing, constructing, and testing a miniaturized “moving liquid gyroscope” prototype capable of demonstrating classic gyroscopic motion and behavior. Students will be required to (1) investigate options for re-engineering solid rotor configurations for operation with liquid components; or (2) propose a new and alternative design concept uniquely tailored for a moving liquid-based rotor. In addition to a demonstration of gyroscopic behavior, the design team shall characterize the operating characteristics of their device and compare these findings with predictions.

Goddard Space Flight Center (GSFC)

Spacecraft to Support a Lunar Mission GSFC1-01-SD, Lunar and Planetary Surface Systems

Engineers would give the students a set of instruments and a lunar orbit and let them design the spacecraft to support the mission. This project would be suitable for a class where the student already knows something of designing spacecraft.

ISAR for Interior Mapping of Asteroid GSFC1-11-SD, Lunar and Planetary Surface Systems

This project has a goal to develop hardware & software for low frequency wideband step frequency ISAR radar. Low frequency ISAR is used to image interior structure of an unknown target such as asteroid/comet and other planetary bodies. ISAR consists of 3 basic subsystems: (1) Base band signal generation and base band I & Q data processing, (2) Analog RF front end, and (3) Antenna. Using either Xilinx/Altera FPGA board and Analog Devices' DDS chips entire base band operation will be programmed and implemented. The analog RF front end will be assembled from commercially available RF components. The data acquisition and processing will be implemented through the FPGA. Development of data processing algorithm to form a 2-D image of interior portion of a target will also be part of this project.

Lunar Transverse Map Challenge GSFC1-12-SD, Lunar and Planetary Surface Systems

1. Develop a process for reducing the now publically available LOLA lunar altitude and slope data with computers and software widely available to American High School and college undergraduate students.
2. Use this procedure to evaluate possible sites for lunar settlements, science stations, mines, and transportation routes.
3. The current state of the project is available at:
Woodware Designs/Mt. Malapert Slope Study
<http://woodwardesigns.com/sky/Malapert/Malapert.html>

Communications, Standards, & Technology Lab
GSFC1-13-SD, Lunar and Planetary Surface Systems

The student intern will participate in the development & integration of technologies and systems into the GSFC Communications, Standards, & Technology Laboratory (CSTL). The CSTL is a facility capable of testing and demonstrating complete end-to-end mission communications scenarios from onboard spacecraft computer systems, ground station RF systems, terrestrial networking systems, to the mission control center. The work available ranges from software development to digital and RF hardware design. Current activities include demonstrations and development of Lunar Surface communications scenarios.

Fabry-Perot Interferometer
GSFC2-05-SD, Ground Operations

Use existing Fabry-Perot interferometer for precise column carbon dioxide measurements and monitoring to make daily-long term measurements of CO₂ column; check calibration/stability of instrument and evaluate data.

Johnson Space Center (JSC)

RISA - Space Environment Monitoring
JSC1-01-SD, Lunar and Planetary Surface Systems

The Remote Image System Acquisition (RISA) multispectral imager has been shown to be able to detect and measure space radiation. Further study is required to determine the usefulness and potential of employing the RISA imager as a space radiation monitoring device. The ability to have a single instrument provide multiple functions is of interest to NASA given limit stowage and power available in the spacecraft environment. This project would include exposing the RISA imager to radiation sources of various types of particles and then analyzing the resulting data to characterize and validate the types of particles being detected. A qualifying university would need to have access to radiation sources and methods to create secondary particles of interest. In addition, temperature monitoring, and other environmental characteristics shall be included in the RISA design to serve to both indicate the ambient environment and for sensor calibration.

[Disciplines: Physics, Nuclear Physics, Biomedical Engineering, Electrical Engineering, Software Engineering, Mechanical Engineering].

RISA - Space Camera 4 (SC4) Development
JSC1-02-SD, Lunar and Planetary Surface Systems

The purpose of the Remote Image System Acquisition (RISA) SC4 project is to produce a high quality / high reliability wireless multispectral imager designed specifically for the space environment. The imager will be used to monitor the health and status of the crew and vehicle

while in space as well as on Lunar and Martian surfaces. The SC4 design will be based on the existing NASA SC3 and SC2 imagers. The project includes the:

- development of required functions in VHDL
- electronic circuit development,
- testing of alternate sensors,
- characterizing the performance of the system using Matlab, and
- design and build of proof of concept prototypes using flight equivalent parts.

Specific tasks to be accomplished within the 201 – 2012 school year include: a) development of an integrated solar powered battery charger, b) development of a wireless Ethernet interface, and c) modifications to support alternate image sensors. [Disciplines: Optical Engineering, Physics, Electrical Engineering, Software Engineering, Mechanical Engineering].

RISA - Multispectral Imaging

JSC1-04-SD, Lunar and Planetary Surface Systems

The purpose of the RISA Multispectral Imaging project is to develop methods to use multispectral imaging for materials identification, locating vegetation, finding evidence of life, identifying environments that will sustain life, atmospheric penetration, biomedical applications, astronomical imaging, and improving methods to identify properties of interest to the NASA mission to meet exploration objectives. Both optical and electrically tunable filters shall be employed for the multispectral imaging objectives. In addition to demonstrating the utility of multispectral imaging, an optical system will be designed, and built which incorporates the multispectral filtering with a lens system. The optical design objectives will explore the use of liquid lenses combined with glass lenses to create a lens system designed to mitigate the effects of the space environment. Proof of concept prototypes will be designed and built. [Disciplines: Optical Engineering, Physics, Astronomy, Biomedical Engineering, Remote Sensing, Electrical Engineering, Software Engineering, Mechanical Engineering].

Advanced Lunar Pressurized Rover

JSC1-06-SD, Lunar and Planetary Surface Systems

Design of a 2-4 person rover for lunar exploration with both robotic manipulator capability and EVA capability. Rover would include minimum gas loss and low power EVA airlock and dust mitigation capabilities. The task would be to design a future lunar pressurized rover that can accommodate 2-4 crew members. This rover would be an element of a future planetary lander. The goal would be to perform surface exploration by creatively designing the layout and the operation of the pressurized rover. The Advanced EVA Technology Group will provide information on concepts from previous studies. Small models of advanced airlocks for rovers that have been proposed could also be provided. High level design requirements for rovers and airlocks from NASA design standards would also be provided.

Lunar Lander EVA Crew/Small Cargo Lifting

JSC1-08-SD, Lunar and Planetary Surface Systems

Design of a system for routinely and safely transporting the EVA crew and small cargo up and down from the airlock to the surface and back, including innovative ladder designs and lifts. The task would be to design a future lunar lander EVA crew and small cargo lifting system. This EVA crew and small cargo lifting system would be an element of a future planetary lander. The goal would be to minimize the overall, mass and weight of a lunar lander crew and small cargo lifting system. The Advanced EVA Technology Group will provide information on the previous designs of crew ladders and some concepts from previous studies

Hand-held Magnetic Dust Removal Brush

JSC1-09-SD, Lunar and Planetary Surface Systems

Since most of the lunar dust is magnetic, a brush with magnetic bristles could be designed to brush the space suit or any other items and the dust would be attracted to it. If the brush was electromagnetic or mechanical where the polarity could be changed, then the poles could be reversed and the dust would be repelled and dropped to the surface after use.

Peel-off Space Suit Visor Protective Film

JSC1-10-SD, Lunar and Planetary Surface Systems

Since the space suit visor will be scratched and get dust after each EVA, design a peel-off film or coating that can periodically be removed so the astronaut can clearly see and not have scratches, especially during long duration missions.

Dust Tolerant Hand Tools

JSC1-11-SD, Lunar and Planetary Surface Systems

Standard tools, such as ratchets, folding handles on tools, and extendable devices, such as tripods will be used during lunar assembly, maintenance, and science tasks. Design some typical tools, such as a folding handle or ratchet, that has mechanisms that are extremely robust and dust tolerant.

Lunar Lander Dust Mat

JSC1-12-SD, Lunar and Planetary Surface Systems

Since there will much walking and preparation at the base of the lander/habitat ladder or stairs after an EVA, and prior to entering the airlock, design a lunar mat or surface so the astronauts are not walking constantly in the lunar dust. This may sound simple, but the requirements are: * light weight, * low volume when stowed, * easily deployed, * dust can be removed or falls between mesh. The crewmembers would prepare sample boxes, repair equipment, dust off on this mat or surface prior to entering the airlock.

Wireless Sensor Scavenging Network

JSC1-15-SD, Lunar and Planetary Surface Systems

Design a wireless sensor energy scavenging network that provides communications to a base station (mobile or stationary) from an array of intelligent sensors nodes comprised of various transducers, sensors, RF transmitters/receivers and controllers with their own power source that does not require batteries to operate. The wireless network sensors obtain power from the environment (power harvesting) and would respond to an interrogation command from the base station to send their data acquisition data to the base station. The wireless sensor scavenging network is programmable for sending data on demand or periodically. In addition, the sensor network can be reconfigured to acquire different types of data from each sensor by the base station. This has applicability for the lunar and beyond outposts. Design includes what trades were made to arrive at the design and concept of operations.

Dust Tolerant EVA Compatible Connectors

JSC1-17-SD, Lunar and Planetary Surface Systems

In the dusty lunar environment, astronauts will be making and breaking various electrical and fluid connectors with their gloved hands. A goal is keep out dust when the electrical or fluid connector is exposed. Design an electrical or fluid connector for lunar exploration with EVA capability. The connector should include dust mitigation capabilities. The task would be to design an electrical or fluid connector for lunar exploration with EVA capability and keeps dust out. These connectors could be on the space suit for recharging the portable life support system or on lunar surface systems for assembly or maintenance. The goal would be to creatively design a connector that is easy to operate with a gloved hand while keeping dust out with minimum crew operations and complexity. The Advanced EVA Technology Group will provide information on concepts from previous studies.

Advanced EVA Airlock

JSC1-18-SD, Lunar and Planetary Surface Systems

Advanced EVA Airlock with Pressure Assisted Airlock Hatches and Dust Mitigation - Due to the expected large number of space walks that will be performed on the lunar surface, innovative designs for an airlock will be needed. Both the internal and external hatches shall be pressure assisted. The EVA airlock should also include minimum gas loss, low power, and dust mitigation capabilities. The task would be to design a minimum gas loss airlock with pressure assisted hatches that accommodate 2 astronauts. This airlock would be an element of a future planetary lander, habitat, or pressurized rover. The Advanced EVA Technology Group will provide information on concepts from previous studies. Small models of advanced airlocks that have been proposed could also be provided. High level design requirements for airlocks from NASA design standards would also be provided.

Producing Oxygen from Lunar Soil

JSC1-19-SD, Lunar and Planetary Surface Systems

America will send its next generation of explorers to many locations. Once there, astronauts will stay in pressurized habitats which must be supported by resources extant on the surface. This project involves the design of prototype in-situ resource utilization systems for resource prospecting and oxygen and methane production.

Traveling Wave Direct Energy Conversion (TWDEC)

JSC1-20-SD, Lunar and Planetary Surface Systems

Traveling Wave Direct Energy Conversion (TWDEC), which functions essentially as a traveling wave tube amplifier driven in reverse, have been identified as a potentially effective technology for extracting energy from the alpha particles produced by aneutronic fusion reactors. The project involves design of TWDEC test articles of benchtop and laboratory scales for evaluation of design options.

Solid Oxide Fuel Cells

JSC1-21-SD, Lunar and Planetary Surface Systems

The ability of solid oxide fuel cells to use pure methane as a fuel with little processing, along with their high temperature heat rejection, make them a very attractive option for spacecraft power generation, when integrated with an oxygen/methane propulsion system. Limitations of this technology include a propensity to crack and leak under temperature swings and to become clogged with elemental carbon ("coke") under the rapid load swings demanded in a spacecraft application. The project involves the development of balance-of-plant designs that flatten out load and temperature swings on a solid oxide fuel cell power plant, as well as research into stack materials that are more durable under load and temperature swings.

Improvements for Space Suits and Equipment

JSC1-22-SD, Lunar and Planetary Surface Systems

Velcro is currently used routinely to attach and removal thermal blankets, close flaps on soft goods containers, and attach and close various components on the space suit, such as the Thermal Micrometeorite Garment (TMG). In this dusty lunar environment, Velcro will allow fine lunar dust to migrate through the Velcro connection and adversely affect equipment. The design challenge would be to improve the current Velcro such as to not degrade its performance and to not allow dust to migrate through it or to design a totally new technology to replace Velcro, but its performance is just like Velcro. This Velcro - like attachment system would have the same requirements as Velcro, such as easily attaches and removes, is flexible and can be sewed to textiles, meets lunar temperature limits, attaches while misaligned, and does not allow dust to migrate through it.

Wall Surfaces Condensation & Evaporation

JSC1-23-SD, Lunar and Planetary Surface Systems

Wall Surfaces that Allow Condensation and Low-Energy Evaporation-One problem with enclosed living spaces is that sometimes surfaces will collect condensation due to a cold surface behind the wall. This water could promote the growth of plant or animal life (mold and bugs!). For this project, you are to investigate how you can design a "wall system" that will trap any condensation that forms, then evaporate it periodically (e.g., every six hours) actively using very little energy or passively when the adjacent air warms above dewpoint. The solution could be a new material, a sensor/heater system, or any other viable design that can be demonstrated on a small scale.

Freeze Back Radiator

JSC1-24-SD, Lunar and Planetary Surface Systems

How would you cool a lunar outpost on the rim of Shackleton Crater? There will be high heat loads when the outpost is occupied plus unoccupied periods of low activity and heat load. One heat rejection system option is a freeze-back radiator of reflux boilers. For this project you will investigate reflux boilers, assess scaling laws for the reduced lunar gravity, build a scaled reflux boiler using commonly available materials, and test its performance.

Electric Propulsion Systems

JSC1-25-SD, Lunar and Planetary Surface Systems

The objective of this project is to do research for the objective of developing propulsion systems that do not require propellant. Fundamental breakthroughs in the physical sciences are required in order to achieve these objectives. Even though the project is based in research, prototypes of concepts and theories will be built and tested. Successful completion of the project is the development of theories, and then the development of electric propulsion lab systems to test those theories.

In this project you will:

- Investigate new forms of electric propulsion that can be used for future exploration objectives. Build prototypes of existing methods of electric propulsion and compare them to alternate methods developed under this effort.
- Research recent breakthroughs in propulsion and develop quantitative results documenting their characteristics.
- Develop new theories of advanced propulsions systems and build prototypes to test concepts.

[Disciplines: Physics, Astronomy, Electrical Engineering, Software Engineering, Mechanical Engineering]

Low Energy/Water Laundry

JSC1-29-SD, Lunar and Planetary Surface Systems

For long-duration human exploration missions including a Lunar Outpost, the clothing system will be a large factor in mission cost. Currently clothing used in space is discarded and is a major source of trash. Clothes washing and drying is expected to be cost effective for mission durations of the order of three months or longer. Aqueous-based systems with extremely efficient water-use are desirable. Initial use will be for lunar surface missions, thus operation in a fractional gravity environment and ability to remove lunar dust will be required. Systems engineering approaches, including synergy with clothing made from advanced fabrics, use of novel detergents or alternative cleaning agents, and compatibility with physicochemical and/or biological regenerative water recovery systems must be considered. This project will involve the design and prototyping of a washing and drying system for re-use of clothing that minimizes requirements for mass, volume, energy, heat rejection, consumable supplies and crew involvement, while meeting toxicity, flammability, out gassing, and human factors requirements.

Clothing for Long Duration Human Exploration

JSC1-30-SD, Lunar and Planetary Surface Systems

Currently clothing is not re-used in space. It is a bulky consumable of considerable mass that must be re-supplied, and once soiled, becomes a solid waste problem. Significant benefit may be realized from improvements to space clothing systems. Advancements in textiles, including high performance fibers, fabrics and materials treatments may benefit clothing systems for future human space exploration missions. Benefits may include reduced mass and volume for storage of clean and used clothing, increased use life, safety for use in enriched oxygen atmospheres, and compatibility with low water and low energy laundering and drying systems, while meeting requirements for crew comfort. Properties of interest include mass, thickness, durability, strength, thermal conductivity, wicking, flammability, linting, off-gassing and antimicrobial characteristics. This project includes the investigation or new materials of changes to existing materials.

ARGOS Advanced Control Algorithms

JSC1-33-SD, Lunar and Planetary Surface Systems

In preparation for returning to the moon, a means must be developed to allow astronauts to practice performing tasks in a reduced gravity environment, and engineers to evaluate systems, such as space suits, used in the performance of these tasks. To these ends, the Active Response Gravity Offload System (ARGOS) is being developed. ARGOS will use electro-mechanical devices and sensors to compensate for the difference between earth and lunar gravity, while keeping the actuation point above the center of gravity during translations. Since mass constraints could result in lunar transport vehicle suspension systems that do not function in earth's gravity, it would be beneficial if ARGOS, or a similar system, could be used to perform "test drives" of development hardware. Of

interest to NASA is a control algorithm that would allow multiple gravity compensation devices to work in tandem to support a large mobile system.

Long Duration Bed Rest Studies

JSC1-39-SD, Lunar and Planetary Surface Systems

The Flight Analogs / Bed Rest Research Project at the Johnson Space Center provides NASA with a ground based research platform to complement space research. By mimicking the conditions of weightlessness in the human body here on Earth, NASA can test and refine scientific theories and procedures on the ground before using these in space. Future space exploration will challenge NASA to answer many critical questions about how humans can live and work for extended missions away from Earth. The Flight Analogs Bed Rest Research Project is one way NASA will answer these questions and devise ways to ensure astronaut safety and productivity on extended missions. Looking forward to support the Vision of Space Exploration, the FAP has developed a Lunar Gravity Simulator which will add to the complement of ground analogs a device to simulate the forces encountered by astronauts on the lunar surface at the FAP facility. The LGS, which reclines a subject at 9.5 degrees of head up tilt, will be the primary method for studying the effects of Lunar Gravity on the human body here on Earth. The LGS will be used by subjects for 16 hours a day for up to 90 days in duration during the long term bed rest studies. The objective of this project will be to develop new and novel approaches for simulating Lunar and Martian gravity for the Flight Analogs Project. The simulators must be designed so that human test subjects are exposed to the forces encountered in Lunar and Martian gravity in the long axis of the body for 16 hours a day and up to a total duration of 90 days. It is desirable that the design will be able to simulate either gravity situation through adjustment on the simulator tilt. The simulators must be able to reside in a standard hospital room, and must meet human factors and safety considerations. It is preferred that the device can accommodate a seated and standing position for the subject with minimal effort for reconfiguration. See also: <http://sk.jsc.nasa.gov/sk211/analogs.aspx>.

Lightweight Electric Vehicle Transmission

JSC1-44-SD, Lunar and Planetary Surface Systems

Vehicles used on the lunar surface will need electric motors. Since the lunar surface will have variable grades and variable masses (due to different payloads in the vehicle), a drive system with a transmission will be needed. A transmission made from steel will be too heavy, so a lightweight, yet reliable transmission is planned. This project includes the design and prototyping of such a transmission. It must be able to operate in the extreme lunar temperature conditions as well.

3-Phase Motor Control

JSC1-45-SD, Lunar and Planetary Surface Systems

High Voltage, High Current 3-Phase Motor Control with PID Control - Vehicles used on the lunar surface will need electric motors. Since the lunar surface will have variable

grades and variable masses (due to different payloads in the vehicle), a drive system with a transmission will be needed. The center of this drive system is a 3-phase brushless DC motor. The motor is expected to use 350 volts and be driven with 30 Amps. The control of this motor (PID or similar closed-loop system) will need to ensure constant torque is delivered and constant velocity is maintained. The design challenges include using such a high voltage, circuit board design that support high currents, and maintaining control stability when the vehicle is decelerating. This project includes the design and prototyping of such a motor control system, including the motor and motor control board. It must be able to operate in the extreme lunar temperature conditions as well.

Cryogenic Component Checkout /Problem Resolution

JSC1-46-SD, Lunar and Planetary Surface Systems

In order for NASA to return to the moon there will be a reliance on cryogenic technologies for use with descent propulsion systems, crew breathing air, and fuel cell reactant storage. As part of it's initial development efforts of these systems NASA is interested in determining whether current off the shelf fluid components, not currently rated for use with cryogenics, can be used in these extreme conditions and if not, what design changes need to be made in order to make them function in a cryogenic environment. The intent of this project will be to receive selected components from NASA's Johnson Space Center for testing with liquid nitrogen and or helium fluids and perform a number of checkout tests. If the component fails checkout testing NASA is interested in understanding what design changes should be made to improve its performance at cryogenic conditions. A comparison with current cryogenic-rated components would be useful.

Horizontal-Axis Washing Machine

JSC1-47-SD, Lunar and Planetary Surface Systems

Clothing and laundry are key technology areas in the Constellation Program. The Constellation Program that will return astronauts to the Moon by 2020 has identified laundering as a likely necessity for life in a lunar habitat.

In a lunar habitat both water and energy are precious consumable. Hence, the best laundering system is that which requires minimum amount of water through all the washing cycles, and requires minimum drying heat and time. The wash load, after the final rinse of the washing cycles, must have the lowest possible Remaining Moisture Content (RMC) to reduce drying time and energy expenditure.

Energy in the conventional h-axis laundering process is consumed during washing by two main mechanisms: heating up the water and running motor and controls, and during the drying operation in three ways: running a fan to blow air, heating the air with an electrical element, and running the motor to the drum. Most of the energy is consumed in heating the air during the drying process. Therefore designing a washing machine that allows for a maximum water extraction from the wash load before drying is highly desirable.

Data Protocols/Data Transmission

JSC1-49-SD, Lunar and Planetary Surface Systems

Lunar surface operations will require interoperability of multiple wireless networks using standard data protocols and frequencies. Specifically of interest is the interoperability of multiple 802.11, 802.15.x, and 802.16 having some or all of their working frequencies in the 2.4 GHz range and the management of these frequencies. Also investigations are needed for the transmission of multiple streams of High Definition Video on these networks. Simulations of the Lunar Surface networks with focus on finding methods of managing the transmissions as to maximize the effective bandwidth of each channel.

Faculty Fellowship- Human Research

JSC1-52-SD, Lunar and Planetary Surface Systems

ESMD's Human Research Program has opportunities for visiting faculty to research human health risks and knowledge gaps working in partnership with JSC scientists, engineers, and physicians. Various areas for research are in the following life science disciplines: bone, cardiovascular, exercise, skeletal muscle, neuroscience, immunology, pharmacology, nutritional biochemistry, space medicine, human factors and environmental health. Topics can be reviewed on the HRP website:

<http://humanresearch.jsc.nasa.gov/about.asp>.

Virtual Windows

JSC1-53-SD, Lunar and Planetary Surface Systems

Legacy NASA spacecraft design suffer from specialized costs and operational constraints associated with embedding optically transparent apertures within structures designed to optimize strength, weight, safety, and environmental integrity. A new approach to the legacy optical window solution may lead to a substantial decrease to program costs while also enhancing crew safety, and functional capability. Changing the paradigm of traditional situational awareness solutions within spacecraft and habitation enclosures has extensive benefits. Instead of optical windows, usage of electronic windows will simplify and open up the trade options for future designs of external structure, especially under environmental demands of extended duration exploration beyond low Earth Orbit. Use of electronic displays as windows also advances the goal of establishing common reusable multipurpose displays for the numerous diverse crew interfaces requiring visual output for humans. This project seeks senior design prototype concepts to stream live video to electronic windows that may accurately mimic optically transparent window viewports. Innovative techniques using commercial off the shelf hardware and software could track an observer's relative position to create perspective controlled video displays or projections with look like real windows. The goal of a windowless or near windowless spacecraft for extended duration transportation or habitation is sought through this

concept project. The deliverables are: the prototype proofs of concept and trade options for future designs.

Splash-down Space Capsule Cooling

JSC4-25-SD, Spacecraft

How do you effectively cool the confined inside enclosure of a just-returned space capsule that is bobbing in the Pacific Ocean? One problem is that there is insufficient energy available in the capsule to run a vapor compression cycle to chill the environment. Can you use the ocean water to cool the air in the capsule? Remember, the temperature of the ocean water at the surface varies, since the capsule can land anywhere between 56 degrees North and 56 degrees South latitude. For this project you will need to investigate the typical ocean temperature, and then design an energy efficient system to use this ocean water to effectively cool the capsule air.

Space Vehicle Transfer Tunnel Automated Mating

JSC4-26-SD, Spacecraft

In the design of the next generation vehicles to be used during NASA's return to the Moon, there is a need to allow crew transfer between vehicles / modules in a pressurized, shirt sleeve environment. This type of transfer is called "IVA (Inter-Vehicle Activity) Transfer". Generically, this type of transfer is performed between any two connected or docked vehicles. The specific case under consideration in this project is the IVA transfer between a Lander Ascent Module (AM) and Airlock (AL). The current lander concept has the IVA transfer tunnel between the AM and the AL pre-mated at Earth launch. The AL remains behind on the Moon and the AM ascends to rendezvous with a vehicle in lunar orbit. The tunnel is pyrotechnically separated and retracted to allow for AM ascent without contact. During a nominal mission, this separation between the AM and AL can be easily managed, as timing is not highly critical. However, in the event of an abort, the tunnel must separate and provide clearance (via retraction) so that the AM does not contact any portion of the tunnel or AL. This retraction must happen very quickly to improve abort reliability. One way to avoid this complication is to fly the mission with the tunnel disconnected. This may provide for increased safety, but adds a serious complication that the tunnel must be mated and sealed in an automated manner once the vehicle lands on the moon. The tradeoff becomes added complexity for automated connection / sealing versus improved safety. This project focuses on the design and potentially fabrication of a mock-up IVA tunnel / connection mechanism and demonstration of the ability to create a pressure seal.

Hydrogen Detection in 100% Humidity Technologies

JSC4-27-SD, Spacecraft

Key to any exploration effort will be generating oxygen for the crew. For example, the Oxygen Generator Assembly (OGA) on the International Space Station (ISS) generates oxygen by electrolysis of water. A current problem of this process is that the oxygen exits the OGA at ambient temperature and pressure, but at 100% relative humidity (RH) due to

un-reacted water vapor. The by-product of the electrolysis process is hydrogen, which is very flammable. Normally, hydrogen is vented from the cabin environment, but there are several hydrogen sensors located in and around the OGA to check for hydrogen leaks. If the hydrogen sensor indicates anything other than nominal, the entire OGA is shut down. "Other than nominal" has, in the past, meant moisture has condensed on the sensor, rather than hydrogen being detected. The design project would be to make this system halt from occurring. The recommended approach is three-fold: 1) attempt to heat the sensor slightly and/or thermally insulate it; 2) create a cold spot upstream of the sensor so that water vapor will deliberately condense away from the sensor and then the condensed water would need to be continuously wick away the water vapor (no gravity available!); and 3) then heat the air back to ambient temperature, resulting in a less-than-100% relative humidity exit stream. This will require applying fluid mechanics of two phase flow in zero gravity, steam thermodynamics, and heat transfer techniques and design. This project and resulting prototype would not need to involve 100% O₂ or H₂ to test the approach.

Miniature General Purpose Measurement Tool

JSC4-34-SD, Spacecraft

In current and future space travel, electronics will play an important part. These electronics are increasingly complex. Occasionally, an electrical or electronics system will fail. In order to troubleshoot the problem, a single handheld instrument is needed. It should have the combined capabilities of a multi-meter, oscilloscope, protocol analyzer, network analyzer, spectrum analyzer, hand held computer, and technical reference database in a rugged, radiation tolerant, easy to use unit. This tool would be the Swiss Army Knife of the International Space Station, Crew Exploration Vehicle and Lunar Habitat Electrical and Electronics Installation and Test. Some capabilities include: Unit should be easily used by an astronaut, with a user interface that can be used in bright sunlight, or dimly lit environment. Use of high reliability universal front end electronics and virtual instrument interface coupled with field programmable analog arrays, and FPGA to maximize universality.

Telemetry in Audio Compression CODEC

JSC4-35-SD, Spacecraft

The Vehicle Orion will utilize the Internet Protocol (IP) for voice and data communications via the radio frequency links to the Mission Control Center (MCC) routing through Tracking and Data Relay Satellite (TDRSS). For redundancy and safety a "dissimilar" audio link will communicate simultaneously with the ground via line-of-sight, during critical mission phases, i.e. launch and landing. This communications link will not be IP but will be digital with compressed audio. The audio speech compressor (Vocoder) will be Conjugate Structured Algebraic Code Excited Linear Predictor (CS-ACELP) as defined by ITU-T G.729. The IP data will be delayed due to the difference in path from the ground to the vehicle, i.e. one is line-of-sight the other via the TDRSS. This project will be to create the algorithms and prototype the system for this redundant audio link. It is the intent to deliver both audio communications simultaneously to the headsets

of the onboard astronauts, without degradation in intelligibility cause by time delay echo. It is desired to encode a short duration, 10-20ms, sync. signal at the beginning of a ground based voice transmission allowing the line-of-sight speech data to be synchronized with the IP voice data, thus presenting the audio to the astronauts headsets simultaneously. A method of reliably encoding sync. data in the G.729 encoder needs to be developed.

Implement Codecs on FPGAs JSC4-36-SD, Spacecraft

This project will be to implement ITU standard G.729 (CS-ACELP) and G.722.2 (AMR-WB) speech compression codecs on FPGA target. These codecs are typically implemented on Digital Signal Processors (DSP). Constellation wants to implement the codecs on an FPGA so that redundant data-bus audio packet management, speech signal extraction and compression can happen on a single chip, minimizing mass, power and size requirements.

Multi-Functional Internal Config. for Lander JSC4-37-SD, Spacecraft

Given the pressurized volumetrics of a lunar lander module, develop the internal configuration for a human crew of four astronauts for 7 days. This module must provide for the habitability of the crew as well as the support functions necessary to accomplish the mission objectives. This project will have applicability to the Constellation Program. The project objective is to design this lunar lander module's functional areas (types required will be provided) in such a way that allows for singular or multi-task activities to occur. Constraints will also be provided (e.g., mass allotments).

Materials Science Radiation Shielding JSC4-41-SD, Spacecraft

This project will involve examining crew dose, materials dose, and avionics single event effects (SEE) environments and how it is affected by manned spacecraft radiation shielding. The project team will use the FLUKA (<http://www.fluka.org/>) ionizing radiation transport code to explore the effectiveness of various materials and materials combinations in attenuation of galactic cosmic ray and solar cosmic ray dose to the interior of relatively massive (compared to robotic vehicles) manned spacecraft. The objective here is to compare different materials in simple geometries so that materials effects on secondary particle production and stopping power can be determined and visualized directly with no complications from specific spacecraft configuration effects. Validation of the FLUKA tool against available space flight data and ground based accelerator data is an essential part of the project. Participants in this project should strongly consider a similar internship available at JSC during the Summer of 2012.

Geomagnetic Storms, TIDs, and Solar Cycle Effects JSC4-42-SD, Spacecraft

Geomagnetic Storms, Traveling Ionospheric Disturbances (TIDs), and Solar Cycle Effects on Neutral Atmosphere-The objective of this project is to evaluate existing (albeit cutting edge) tools used to predict the scale of the ISS attitude control or satellite drag anomalies expected as a result of geomagnetic storm events or as the upper atmosphere become immediately denser during geomagnetic storms and gradually denser as we approach the upcoming solar maximum, the magnitude and character of which is proving more difficult to predict than was the case for the last several solar maxima. Participants in this project should strongly consider a similar internship available at JSC during the Summer of 2012.

ISS as a Nano/Micro Satellite Base JSC4-43-SD, Spacecraft

International Space Station as a Nano/Micro Satellite Base-This project is an evolution of the sounding rocket base (Wallops, White Sands, Poker Flats etc.) idea as suggested by the free launch services provided for micro satellite and nano satellites by ESA on the Arienne launcher and used extensively by Surrey Satellite customers. Specifically, the project team will need to provide a report with the following information: a) Feasibility - assessment of earth-to-orbit transportation opportunities to ISS in the post Shuttle era. b) Concept - multi-satellite carrier to attach to ISS externally and provide controlled mechanical deployment/launch over some range of vectors compatible with ISS safety (collision avoidance). c) Launch opportunities for satellite carrier assembly - Progress, Soyuz, ESA/ATV, JAXA/HTV, Commercial Carriers (COTS Program), Orion. d) Matching the concept to the agency road maps and science objectives/needs of, for example, the National Science Foundation, NASA Science Mission Directorate, and the National Oceanics and Atmospheric Administration. Participants in this project should strongly consider a similar internship available at JSC during the Summer of 2012.

Reusable Electronic Structures JSC4-48-SD, Spacecraft

Reusable electronic structures for reduced power usage and reduced electronics footprints-Many electronic circuits have common sub-circuits and sub-elements that are not utilized full time. It is theorized that common sub-circuit elements could be reutilized or loaned to other circuits while they are not being used. With the advent of Field Programmable Gate Arrays (FPGA) or Field Programmable Analog Arrays (FPAA) the reality of sub-circuit reutilization and loaning could be a reality. The logistics of sub-circuit allocation now becomes more of a circuit management and availability issue. The availability and scheduling could be performed by an integrated or remote microprocessor. This project's goals are to define the common sub-circuit elements, develop scheduling and management tools and algorithms that facilitate effective circuit reutilization, borrowing and loaning, that effectively reduce total circuit power, footprint and overall costs.

CubeSat: Nanoelectronics Testing for Radiation

JSC4-50-SD, Spacecraft

Spaceflight testing of advanced nanoelectronics: Developing a CubeSat compatible space radiation flight test system. Goal: Design, fabricate, simulate, and bench test a low cost on-orbit system for assessing the reliability and survivability of advanced (nanometer) semiconductor components and systems in space radiation environments. The physical size and data/power requirements of the test system should be compatible with flight on any of the following vehicles or platforms: 1) CubeSat, 2) ISS MISSE-X, 3) ISS internal (pressurized volume) payload rack, 3) GSFC Space Cube, 4) GSFC/DoD METB.

Acoustic Properties of Space Flight Materials

JSC4-51-SD, Spacecraft

This project is to develop hardware and software to measure the acoustic absorption and transmission loss characteristics of potential and actual space flight approved materials in the frequency range from 250 Hz to 8kHz, using the ISO 10534-2 standard and other related standards. Noisy equipment and hardware including scientific experiments, pumps, and ventilation systems aboard current and future manned space platforms constitute a safety and communication hazard for the crew. The standard method for noise abatement is to use sound absorbing and sound blocking materials or mufflers; however, any new or modified flight approved hardware must meet all flight specifications. Flight approved materials used for noise abatement must be lightweight and nonflammable; additionally, approved materials must not outgas or be friable. The results of this project will include the Space Flight Acoustic Materials Database and will be available for use by spaceflight hardware developers.

Wearable Smart Fabric Crew Communicator

JSC4-54-SD, Spacecraft

NASA is pursuing developing the technology for future human missions beyond Earth orbit. Present spacecraft crew communication systems require hand held communication devices that plug into spacecraft communications systems. This results in communication cables intrusively floating in the crew space as well as limiting the freedom to float around the crew cabin. It is desired that the crew communication device be built into the crew-work garments, thus freeing up the crewmembers hands and eliminating interfering floating cables. This project seeks senior designing prototype concepts in a Wearable Smart-Fabric-Crew-Communication Device (WSCD). It is desired that the WSCD be of a smart fabric design (sewed into garment) that provides full-duplex digital wireless voice communications. In addition, the prototype design goals are: should be power efficient (battery life of at least 2 hours, in continuous mode of operation); contain simple controls for on/off, volume control, and enable/disable voice communications; provide visual indicator of power status; operate with a minimum wireless range (should be at least 20ft.); maximum weight of the WSCD, including battery, should be no greater than 2 oz.; operate with a background noise of 60dB; and speaker peak volume output at least 70 dBSpl @ 1 ft. The deliverables are: the

prototype unit integrated into a shirt, the schematic, the software code, any PCB layouts, and a design description document delineating the theory of operation. Review Sparkfun.com E-textile products as a starter. Estimated material cost ~\$2K.

Kennedy Space Center (KSC)

Lunabotics Mining Competition - Regolith Excavation

KSC1-05-SD, Lunar and Planetary Surface Systems

The Lunabotics Mining Competition is a university-level competition. NASA will directly benefit from the competition by encouraging the development of innovative lunar excavation concepts from universities which may result in clever ideas and solutions which could be applied to an actual lunar excavation device or payload. The challenge is for students to design and build a remote controlled or autonomous excavator, called a lunabot, that can collect and deposit lunar simulant. The complexities of the challenge include the abrasive characteristics of the lunar simulant, the weight and size limitations of the lunabot, and the ability to control the lunabot from a remote control center. See website for more information and to register for the competition: www.nasa.gov/lunabotics.

Lunar Operations Cryogenics Consumables

KSC1-06-SD, Lunar and Planetary Surface Systems

Lunar Operations Cryogenics Consumables Transfer-Oxygen that is produced on the moon must be transferred to the end user. In addition there will be residual propellants on the descent stage that can be scavenged and re-used as valuable commodities. This project will identify methods for cryogenics consumables transfer and appropriate dust tolerant interfaces.

Umbilicals and Quick Disconnect Couplings

KSC1-07-SD, Lunar and Planetary Surface Systems

Umbilicals and Quick Disconnect Couplings for Lunar Cryogenics Consumables Transfer-A Quick Disconnect (QD) Fluid Coupling that is dust tolerant and does not leak is required for transferring cryogenic and other liquid consumables on the moon.

Dust Mitigation Technology

KSC1-14-SD, Lunar and Planetary Surface Systems

The NASA Kennedy Space Center Electrostatics and Surface Physics Laboratory has the responsibility for the development of new instruments and methods to measure the

electrostatic properties of granular and solid materials, the calibration and testing of electrostatic sensors being developed, the performance of surface analyses of electrostatically charged objects, and the study of new materials with low electrostatic affinity. The laboratory is developing technologies to alleviate dust accumulation and deposition onto equipment under lunar and Martian environmental conditions for future exploration missions.

Electrostatic Charge Generation on Spacecraft KSC1-15-SD, Lunar and Planetary Surface Systems

The NASA Kennedy Space Center Electrostatics and Surface Physics Laboratory carries out electrostatic analyses and materials characterization to assist in the detection, mitigation, and prevention of electrostatic discharge generation and its effects on space flight hardware and on ground support equipment. The laboratory is developing methods to accurately determine triboelectric charge generation on spacecraft traversing ice clouds at supersonic speeds immediately after launch. The laboratory will also develop methods to mitigate this charge buildup.

Packetized Telemetry Converter KSC2-01-SD, Ground Operations

Utilizing reconfigurable logic devices, develop a system that accepts packetized telemetry (reference CCSDS 702.1-R-1, 714.0-B-1, 727.0-B-3 and 732.0-B-2) and outputs a PCM stream compatible with IRIG-106-05 Ch.4 for input to existing ground based telemetry processors. The intent of this project is to determine whether existing KSC telemetry processing devices can be utilized in the packet telemetry environment or if all the PCM based devices need to be replaced. The suggested use of FPGA type devices is to provide the flexibility to update the translation routines without requiring hardware change-out. Other implemenations could and should be considered.

Universal Wireless Sensor KSC2-11-SD, Ground Operations

Recent developments in the availability of low cost, low power microcontrollers have underscored the amazing things one can do in integrated silicon in today's market. In particular, there is an ever increasing trend to integrate more peripheral's into modern microcontrollers including additional A/D channels, digital I/O, serial communication interfaces, analog comparators, and Pulse width modulation channels for analog outputs with prices starting at under \$0.48 and averaging less than \$5.00. As an example consider the device from ATMEL semi, the 8-bit RISC processor, ATMEGA168, with a single unit price of ~\$4.00

Device: Flash (Kbytes) EEPROM (Kbytes) SRAM (Bytes) F.max (MHz) Vcc (V) 16-bit Timers 8-bit Timer PWM (channels) RTC SPI UART TWI ISP 10-bit A/D (Channels) Analog Comparator

ATmega168 16 0.5 1024 20 1.8-5.5 1 2 6 Yes 1+USART 1 Yes Yes 8 Yes

This unit has (8) 10bit A-D channels, 6 analog output channels (PWM), has serial communication interface built in, and can operate from off the self alkaline batteries for weeks. This is in contrast to a typical programmable logic controller deployment with KSC's ground power system which involves over \$10K in controller hardware for a very similar IO count. More recently, microcontroller vendors have begun to offer wireless communication chipsets that are designed for integration with their controller lines.

While many of the products that will emerge have not made it to market yet, the simplicity of the hardware all but guarantees they will. However, the time constants in the R&D cycle as well as UL listing often delay products to market. This makes for an excellent opportunity to develop ahead of the private sector a wireless device suitable for KSC use that costs under \$20.00 in materials and is fully functional in KSC ground applications. Proposed Requirements:

I/O Capability: (1) Support Analog input with 10 bit or better resolution AND (1) digital sensor using I2C, TWI or other standard serial interfaces

Sample Rate: Variable based in battery life requirements but be configurable from 1 sample/minute to 100kSamples/sec

Power Requirements: Make use of controller sleep and standby modes to extend battery life to fullest extent

Size: Limited to one 2"x4" single layer PCB

Connectivity: Transmit wirelessly over Zigbee IEEE 802.15.4 and via USB to a laptop

Data Storage: Support onboard data storage or remote poll via Zigbee.

Cost: Under \$20.00 BOM for 10k units

Project Program: Microcontroller specific C Code

Deliverables:

(1.) (3) Demo units configured to demonstrate Zigbee's mesh networking capabilities with both digital and analog sensor inputs

(2.) C code for entire project

(3.) Development tools if not freeware (ATMEL development environment is totally free)

(4.) PCB layout files so that the government can produce at its leisure from PCB express or other online builders..

Cryogenic Fluid Management

KSC2-12-SD, Ground Operations

Thermodynamics and refrigeration analysis for planning the Integrated Ground Operations Demonstration. This project will include zero loss LH2 launch site storage and transfer using high efficiency transfer lines and cryogenic refrigeration systems.

Corrosion Resistant Flame Trench Refractory

KSC2-13-SD, Ground Operations

Design materials expertise in developing component level system/testbed for testing refractory materials that must provide acceptable performance and maintain integrity during/after exposure to launch environment conditions, without spalling and with minimal cracking.

Langley Research Center (LaRC)

Lidar Systems for Sensing Trace Gases

LARC1-17-SD, Lunar and Planetary Surface Systems

Lidars for sensing water vapor, ice, and several atmospheric trace gases are being investigated. Students will develop computer models for evaluating the merits of several lidar techniques for optimum system development. There could be some test experiments, provided students have requisite training in using lasers that includes laser safety training and eye exams.

DIAL for Water Vapor Detection

LARC1-18-SD, Lunar and Planetary Surface Systems

Mid-IR Laser-Based Differential Absorption Lidar (DIAL) for Water Vapor Detection-Students will be involved in developing the capability (modeling and simulation) of sensing water vapor on Mars and in other planetary atmospheres using lidars. There could be some test experiments provided students have requisite training in using lasers that include laser safety training and eye exams.

Modeling and Simulation for ASCENDS

LARC1-25-SD, Lunar and Planetary Surface Systems

Lidar performance modeling and simulation for ACTIVE SENSING OF CO₂ EMISSIONS OVER NIGHTS, DAYS, AND SEASONS (ASCENDS) program. Tasks include direct detection lidar performance simulation, instrumentation modeling, investigation of modulation techniques to support CO₂ and O₂ lidars.

Ambient Display Visualization

LARC2-27-SD, Ground Operations

Ambient Display Visualization of Operator Functional State-This project seeks to create and test an ambient display which visualizes physiological indicators to intuitively communicate the functional state of an operator in a simulation scenario.

Brainwave Signal Simulator

LARC2-28-SD, Ground Operations

Design and construct a signal simulator for testing electroencephalographic (brainwave) instrumentation. The design could be software or a digital stand alone instrument-possibly modeled after an audio graphic equalizer.

Biocybernetic Test Station

LARC2-29-SD, Ground Operations

Reconstruct the closed loop capability reported in the 1995 paper, "Pope, T., Bogart, E. H., and Bartolome, D. S. (1995). Biocybernetic System Validates Index of Operator Engagement in Automated Task. Biological Psychology, 40, 187-195," in a test station form. The updated implementation would likely use Matlab interfaced with a physiological monitoring system.

Modulated Virtual Environment

LARC2-30-SD, Ground Operations

Design and construct a synthetic vision system that feeds a virtual environment in and out, driven by physiological signals. The virtual environment could be a simulation of an aircraft flight deck or other transportation controlled environment.

Mars Lander Educational Display

LARC4-13-SD, Spacecraft

The primary objective for this project is to develop an educational display and/or software emphasizing the challenges of entry, descent, and landing on Mars. The user would become the "engineer" and solve problems related to landing on a planet that has an atmosphere.

Scaled Spacecraft and Test Apparatus

LARC4-19-SD, Spacecraft

Scaled Spacecraft and Test Apparatus to Enable Assessment of Water Landing for Orion-Type Vehicles-This work is important in the context of the development of the Orion Landing System and has potential for future spacecraft design. The focus of the undergraduate engineering design team will be the design and fabrication of a scaled capsule and testing apparatus for landing in water. The model of the Orion spacecraft should land in water with various combinations of horizontal and vertical velocities and impact attitudes in a parametric study. Measurements of interest will be tri-axial accelerations at the center of gravity and pressure variation on the heatshield.

Chemical Composition of Nanomaterials

LARC4-20-SD, Spacecraft

This project involves the characterization of the chemical composition of nanomaterials for aerospace applications using energy (or wavelength) dispersive spectroscopy, x-ray diffraction, atomic absorption (or emission) spectroscopy, mass spectrometry, and/or nuclear magnetic resonance spectroscopy. The materials will be provided to the project team by the NASA POC. The overarching purpose of this and related projects is to understand the morphology and mechanical, electrical, magnetic, and chemical properties

of the fabricated materials and then attempt to correlate those results to the modeled and observed nanoscale structures.

Surface Conductivity of Nanomaterials

LARC4-21-SD, Spacecraft

This project involves the characterization of the surface conductivity of nanomaterials for aerospace applications using a four-point probe for mapping. The materials will be provided to the project team by the NASA POC. The overarching purpose of this and related projects is to understand the morphology and mechanical, electrical, magnetic, and chemical properties of the fabricated materials and then attempt to correlate those results to the modeled and observed nanoscale structures.

Surface Energy of Nanomaterials

LARC4-22-SD, Spacecraft

This project involves the characterization of the surface energy of nanomaterials for aerospace applications using contact-angle goniometry. The materials will be provided to the project team by the NASA POC. The overarching purpose of this and related projects is to understand the morphology and mechanical, electrical, magnetic, and chemical properties of the fabricated materials and then attempt to correlate those results to the modeled and observed nanoscale structures.

Electromagnetic Materials of Nanomaterials

LARC4-23-SD, Spacecraft

This project involves the electromagnetic materials characterization of nanomaterials for aerospace applications. The materials will be provided to the project team by the NASA POC. The overarching purpose of this and related projects is to understand the morphology and mechanical, electrical, magnetic, and chemical properties of the fabricated materials and then attempt to correlate those results to the modeled and observed nanoscale structures.

Surface Roughness of Nanomaterials

LARC4-24-SD, Spacecraft

This project involves the characterization of the surface roughness of nanomaterials for aerospace applications using an atomic force microscope. The materials will be provided to the project team by the NASA POC. The overarching purpose of this and related projects is to understand the morphology and mechanical, electrical, magnetic, and chemical properties of the fabricated materials and then attempt to correlate those results to the modeled and observed nanoscale structures.

Centrifugally Stiffened Solar Sails

LARC4-26-SD, Spacecraft

Structural Dynamics and Deployment of Centrifugally Stiffened Solar Sails-Centrifugally stabilized solar sail structures present a challenge to flight qualification in that full-scale ground deployment testing is not feasible. The objectives of this project are: 1) design the largest spinning solar sail craft packageable within an existing launch vehicle, and 2) design a sub-scale deployment and dynamics test article, relevant to the full-scale design, that is capable of being evaluated aboard ISS as a microgravity flight experiment.

Marshall Space Flight Center (MSFC)

Radiation Effects on Electronics Modeling

MSFC1-07-SD, Lunar and Planetary Surface Systems

Develop advanced models of the natural radiation environment to diagnose and predict the effects of Single Event Effects (SEEs) on modern electronic architectures.

Reconfigurable Computers

MSFC1-08-SD, Lunar and Planetary Surface Systems

Provide reconfigurable computing capability, resulting in reduction of flight spares and risk reduction for limited circuit lifetimes.

Space Materials and Solar Energy Self-reliance

MSFC1-13-SD, Lunar and Planetary Surface Systems

Design a self-supporting system for a space outpost using lunar, Mars, or asteroid materials and solar energy. The system can supply any necessity for the astronauts (water, oxygen, spare parts, food etc.)

Planetary Instrument Sample Collection Device

MSFC1-14-SD, Lunar and Planetary Surface Systems

Marshall Space Flight Center has been developing a miniaturized Scanning Electron Microscope for in situ imaging and chemical mapping of samples for use on the Moon (as well as other planetary bodies.) This project would require the mechanical design and prototyping of a sample collection scheme that would take samples from the lunar surface and introduce them into a sample chamber for analysis. A fully automated sample collection device would allow for the instrument to be operated remotely from a rover. Some key considerations instrumental to this design are dust mitigation, selectable sample size, temperature fluctuations on the lunar surface, and compactness of design.

NASA X-TOOLSS

MSFC1-20-SD, Lunar and Planetary Surface Systems

Description: Use of the NASA eXploration Toolset for Optimization Of Launch and Space Systems (X-TOOLSS) software for design optimization of conceptual space systems. NASA X-TOOLSS is based on genetic and evolutionary algorithms, which have proven successful for global optimization of complex systems, and for applications where unique and innovative designs are sought. An advantage of NASA X-TOOLSS and genetic/evolutionary optimization is that the design space is not limited to existing designs and approaches. Example applications of interest for NASA X-TOOLSS include habitats for the Moon and Mars, lunar surface mobility and power systems, lunar descent module and lander concepts, and thermal/structural design of small satellites and other spaceflight hardware.

Lunar Regolith and Simulants

MSFC1-22-SD, Lunar and Planetary Surface Systems

MSFC is developing a method to create lunar regolith simulants that will match the properties of the lunar surface. This process requires preparation of silicate mineral separates from igneous rocks. Design, testing and cost analysis of a system able to produce batches of separates between 1 and 100 tons is needed. A successful method will be an important step in an overall effort involving a dynamic national and international team.

Lunar Composting Capability

MSFC1-23-SD, Lunar and Planetary Surface Systems

Composting of human food and other waste on the moon will be desirable, both from the standpoint of reuse of biochemicals (in support of long term habitation) and in order to protect human health. While composting in lunar soil may be desirable, it may not be feasible. Lunar soil is, in contrast with most earth soils, completely mineral. More importantly, it is believed to be mechanically, and possibly chemically, hazardous to biological systems. Semester 1: Assess existing literature; identify sources of unpublished data and evaluate publication of recovered information. Characterize the risks and benefits of use of lunar soils for composting food wastes, paper and cardboard, and sewage. Address each type of waste separately and in combination, as well as microbiological culture required. Develop design concepts for a composting system. Plan testing that addresses regolith simulators and effects of gravity; document in a test plan. Semester 2: Execute complete design based on concepts. Fabricate and assemble. Conduct testing defined in test plan and execute report.

Lunar Habitat Situational Awareness

MSFC1-24-SD, Lunar and Planetary Surface Systems

In order to provide radiation shielding, thermal insulation, and impact protection, the covering of the lunar habitat will be very thick, likely including regolith. Physical windows in the habitat hull will be limited at best. Suggest schema and technologies to allow the crew to be kept informed (without constant human monitoring of the hemisphere around the habitat. System requirements would include, but not be limited to, planning and coordination of multiple Extra Vehicular Activities (EVA); habitat integrity monitoring; and recording of environmental events, such as meteoroid strikes or passages, and solar energetic events. The system should consist of internal controls and displays in the habitat and the external means to gather information. Multispectral data collected simultaneously (visible, IR, UV, and high energy) may be useful. Consider methods such as “difference modeling” to extract crew-useful information from the collected data. Semester 1: Develop the concepts for the situational awareness system. Address cost, mass, and volume, as well as where the system components would be located both inside and outside the module. Describe the technologies to be used and note which are commercially available and which need further development. Semester 2: Prototype the system and demonstrate its capabilities. Propose further work.

Design of Lunar Garage

MSFC1-25-SD, Lunar and Planetary Surface Systems

NASA will need a garage facility to repair & maintain Lunar Roving Vehicles (LRVs) once we return to the moon. The garage could be pressurized for a shirt sleeve environment or unpressurized for a space suit environment or perhaps both (unpressurized for minimal maintenance, pressurized for more extensive repairs). Semester 1: Using the size of the Apollo LRV as a guide to the vehicle size to be accommodated, propose concepts for the garage using minimal launched mass as a major constraint. This might lead to an inflatable design, or one built from regolith in sand bags for example. Consider what tasks might need to be done on the LRV, based on the Apollo experience, and provide clearance in the garage for the work to be done by two crew. Plan evaluation activities and document in test plan. Semester 2: Construct & test the garage based on the overall design constraints formulated during the first semester.

Partial Gravity Crew Interface Design

MSFC1-26-SD, Lunar and Planetary Surface Systems

The microgravity experience has illustrated the need to accommodate the differences in human performance due to different gravity fields. NASA's short term interest is in 1/6 g for lunar habitats, but is also in 1/3 g for Mars. Appropriate architectural design for habitats requires establishing partial Gravity Crew interface design principles such as the transition angles between ramps, stairs, stair ladders, and stairs. These are well established for 1 g, but are still unknown for 1/6 & 1/3 g. Semester 1: Propose methods to determine the transition angles for lunar habitats. Document in test plan. Semester 2: Carry out the experiments and determine the transition angles for 1/6 g, and (time permitting) 1/3 g.

Longterm Radiation Protection for Lunar Habitats

MSFC1-29-SD, Lunar and Planetary Surface Systems

This project will investigate methods for designing a habitat that can have additional radiation protection added over time to permit longer and longer mission durations at a permanent outpost site on the lunar surface. Radiation protection options have included adding water to interior cavity walls, water bags on the exterior (perhaps frozen), compacted trash on the exterior, flattened logistics bags added like blankets over the exterior, bagged regolith or a loose regolith covering over the exterior, or combinations of all of these methods. The initial habitat will start with a 5g per cm² water wall around the sleeping compartment as a minimum protective shelter for the crew during solar proton events (SPE). The goal will be to eventually reach 20g per cm² of any material over the entire habitat for protection from both SPE and galactic cosmic rays (GCR). Publically available information on the design of International Space Station (ISS) modules and current published designs for lunar outpost modules should be used as a basis for the outpost concepts. Crew size will start at a minimum of 4 for 12 days and will increase to longer crew rotations for year-round occupancy supporting 8 crew during rotations. In analyzing each approach designers will be required to minimize crew extra-vehicular activity (EVA) time, minimize additional mass deliveries to the surface, utilization of residual resources from Lander propulsion and power systems, utilization of crew logistics waste products (logistics bags, plastic wrap, etc.) and utilization of local regolith and natural terrain features. In addition, designers will need to consider how to handle supporting utilities that are usually attached to the exterior of the modules (solar panels, radiators, communications equipment, etc.). The text "Human Spaceflight: Mission Analysis and Design" edited by Larson and Pranke should be used as a reference for logics, Lander, and habitat design basics.

Toolset for Launch Vehicle/Spacecraft

MSFC1-30-SD, Lunar and Planetary Surface Systems

Multidisciplinary Toolset for Evaluation of Launch Vehicle and Spacecraft Conceptual Designs-This project continues a several year effort to develop a toolset of computational models in fluid mechanics, structures, thermal analysis, magnetohydrodynamics, nuclear/radiological and rarefied gases.

Propellant Loading in Launch Vehicle

MSFC2-28-SD, Ground Operations

MSFC has developed a Generalized Fluid System Simulation Program (GFSSP) for modeling and simulation of propulsion systems. GFSSP is a finite volume based network flow analysis code that can model cryogenic propulsion systems. This program has been extensively used for Tank Pressurization, Chilledown of Cryogenic Transfer Line, Loading of Propellant Tank and Feed System Design. GFSSP can be used for developing Senior Design Project to develop timeline for Launch Service Program and Design of Propulsion Feed System.

Nuclear Fission Surface Power Design

MSFC3-06-SD, Propulsion

This project will focus on the design and potential utilization of a 20/40 kWe Fission Surface Power System for use anywhere on the surface of the moon or Mars. The project will include performing a top level design of the Fission Surface Power System, including the reactor, shield, power conversion, power management and distribution, and radiator. Potential uses of the electrical or thermal energy from the reactor should be identified. Methods for emplacing and deploying the system should also be discussed. Emphasis should be on systems that minimize programmatic risk and utilize well proven technologies.

Liquid Engine System Performance

MSFC3-12-SD, Propulsion

To further develop PSTAR, the first order modeling tool, by providing the capability to perform off-design analysis of liquid rocket engines, while improving performance, weight and cost predictions. There are up to 4 senior design projects available -- off design capability, performance improvements, weight model improvements and cost model improvements.

Diagnostics for Plasma Propulsion Systems

MSFC3-16-SD, Propulsion

Plasma-based systems are typically applied to situations where very high gas velocities are required. As a space thruster, plasma-based devices expel their propellant at a much greater velocity than chemical rockets. Consequently, they require less propellant to complete a given mission, leaving more room on a spacecraft for hardware/consumables/instruments. Plasma based devices also find use in studies where the fast plasma can be used to accelerate small particles up to the speeds typical of in-space micrometeorites impacting a spacecraft or habitat. There is a need to have diagnostics that can measure the time-varying plasma properties in such devices to validate the present theoretical understanding and to serve as experimental benchmarks that can support the development of models. Senior project opportunities are available in designing and constructing robust, stand-alone diagnostic packages with plug-n-play capability for use with many pulsed plasma sources and in designing and fabricating experiments for evaluation of new diagnostic techniques.

Liquid Metal System for Nuclear Surface Power

MSFC3-17-SD, Propulsion

There is presently an effort underway at MSFC to evaluate components that might be included in the design and eventual deployment of space and lunar-based nuclear reactor systems. The evaluation effort involves the use of a simulated nuclear reactor core (comprised of resistive heating elements) where pumped NaK (sodium-potassium eutectic) is used as the heat-transfer medium. In these systems there is significant need for improvement over present state-of-the-art component technology. This includes the

need for lighter-weight, more efficient liquid metal pumps, more accurate flow rate measurement techniques, and capabilities to monitor the state of the liquid metal (liquid level, temperature, etc), especially in locations that are not easily accessible. Senior projects would aim at evaluating different strategies to improve technology over the present state-of-the-art through a combination of literature research, theoretical and numerical modeling, performance analysis, fabrication and testing.

ROCETS Improvements

MSFC3-18-SD, Propulsion

To improve the Rocket Engine Transient Simulation (ROCETS) tool by making the optimization scheme more robust, adding new design modules and improving existing modules.

Propulsion System / Turbomachinery by GFSSP

MSFC3-19-SD, Propulsion

GFSSP (Generalized Fluid System Simulation Program) is a finite volume based network analysis code developed at MSFC for analyzing chilldown, loading, stratification, pressurization, feed system, recirculation and fluid transients. It has also been extensively used for secondary flow analysis in turbo-pumps and many other applications that require coupled thermo-fluid analysis involving conjugate heat transfer. GFSSP has an user-friendly visual pre and post processor and a modular code structure with extensive documentation with example problems that make it ideally suitable for Senior Design Project.

Analyze, Build, and Flight-test Rockets

MSFC3-27-SD, Spacecraft

Analyze, build, and flight-test rockets to develop systems engineering skills. A rocket is to be built that will target an exact altitude which lies between 3500 ft and 7500 ft (above ground level). The target altitude is negotiable, but must be declared at the start of the project, and must be achieved within a band of $\pm 1\%$. A trajectory algorithm is to be written to predict the position, velocity, and acceleration of the rocket from liftoff to touch down. The trajectory algorithm is to be anchored with data from a series of ground and flight tests. Other pertinent engineering parameters (eg., drag as a function of velocity or time, tank pressure as a function of burn time (for propulsion systems which use fluid propellants), motor chamber pressure, etc.) should also be predicted, measured, and correlated. It is strongly encouraged, but not required, to incorporate an active onboard energy management system into the rocket system to more precisely achieve the target altitude.

Design for Reliability and Safety

MSFC4-01-SD, Spacecraft

Safety and Reliability is a top priority for NASA in the development of new launch systems. There is a need to define and develop a process that describes how to "design for reliability and safety". This is a system engineering design project that addresses all what needs to be done throughout all the phase of a program (quantitative and qualitative) to design highly reliable and safe launch systems. This includes identification of products, tools, approaches, etc.. by program phase.

De-Orbit Propulsion Systems

MSFC4-23-SD, Spacecraft

Optimized De-Orbit Propulsion Systems for Various Mass-Class Payloads-NASA classifies satellites as standard (>500 kg range), small (100-500 kg range), mini (10-100 kg range), and nano (less than 10 kg). Each size satellite has associated volume constraints which together define the launch mass and volume of the payload. All spacecraft programs are required to have a de-orbit plan for all satellites in Low Earth Orbit. This study will focus on determining the optimum de-orbit system for each of the satellite sizes. The de-orbit systems to be considered are: 1. solar sail, 2. chemical /liquid fuel thruster, 3. natural decay, 4. electro-dynamic tethers, 5. other. To normalize the study, start by considering all satellites at an altitude of 1000 km, in a circular orbit, and 28.5° inclination. To start the study, assume the following masses: Standard = 500 kg Small = 250 kg Mini = 50 kg Nano = 5 kg The study should evolve into optimization over available trade space.

Remediation of Pollutants by Non-Mechanical Technologies

MSFC4-24-SD, Spacecraft

Current technologies for removal of toxic and hazardous materials from life-contact fluids (air, wastewater) include filters and chemical exchangers that must be discarded after use. The limitations on mass that can be carried on long-term missions to the moon and Mars will demand that regenerative capabilities be developed to remove biological materials, outgassed abiological compounds, and lunar dust from water and air. Semester 1: Develop concepts for remediation technologies that could be achieved within 15 years. Address regenerative abiological chemistries, nanotechnology, and biological or biochemical systems. Develop proposal for construction of one or more systems, including test plan. Semester 2: Develop system and conduct appropriate tests, based on test plan. Report results.

Stennis Space Center (SSC)

Data Acquisition and Control System

SSC1-06-SD, Lunar and Planetary Surface Systems

Data Acquisition and Control System development for portable hybrid technology demonstrator rocket-The student team is to design and build a data acquisition and control system for Stennis Space Center's (SSCs) portable hybrid technology demonstrator rocket (pocket rocket). SSC is to provide a schematic for and a loaner pocket rocket. SSC will also provide design requirements for the project, such as instrumentation uncertainty and propellant flow rate.

Design of a Shell Tube Heat Exchanger SSC3-03-SD, Propulsion

When discussing space travel (including satellite launches), there is and always has been a desire to lift as much payload as possible at the lowest cost possible. In fact, SSC has been asked to deliver 162 degree Rankine Liquid Oxygen (LOX) to support testing of X-33, J-2X Powerpack and recently SSME. This was accomplished by "bubbling" gaseous helium through the LOX storage vessel until the desired temperature was achieved. This "denser" propellant enabled the rockets to achieve better engine performance. Recently, a customer approached SSC with a desire to test with 150 degree Rankine LOX, which is outside of the capability of "bubbling". The customer described a shell tube heat exchanger type apparatus used in conjunction with Liquid Nitrogen to achieve temperatures as low as 145 degree Rankine in a previous project. This heat exchanger would not be available for our testing series. We need to design a shell tube heat exchanger (and associated piping) which uses Liquid Nitrogen to achieve 145 degree Rankine LOX. The actual storage vessel to be used is an 11,000 gallon Liquid Oxygen tank and the required time to decrease LOX temperature is 12 hours maximum. Proof of concept can be done on a much smaller scale to demonstrate proper operation.

Cryogenic Pipe Stress SSC3-05-SD, Propulsion

At NASA Stennis Space Center the use of cryogenics is very important to the testing of rocket engines used for space exploration. It is important to know the characteristics of piping that carry cryogenic fluid to the testing stands. For this project we need to be able to evaluate piping surface temperature and stress as a function of flow condition (full LN flow, trickle LN flow and no flow) and environment for a pipe containing Liquid Nitrogen (LN). For example, if the pipe is chilled with LN we should be able to measure the surface temperature and pipe stress for the different flow conditions. Next we should be able to expose the top of the pipe to sunlight and rain to see how that affects the pipe outer temperatures and stresses along with the varied flow conditions. The collected data should be compared with a model of the system in ANSYS or equivalent software.